Simpson®

INSTRUMENTS THAT STAY ACCURATE

OPERATOR'S MANUAL

SIMPSON 2750-2
STRIP CHART RECORDER
& SIMPSON 2760-2
TEMPERATURE RECORDER

⚠WARNING

READ AND UNDERSTAND THIS MANUAL BEFORE USING THE INSTRUMENT.

Failure to understand and comply with the WARNINGS and operating instructions can result in serious or fatal injuries and/or property damage.

SIMPSON ELECTRIC COMPANY
853 Dundee Avenue, Elgin, Illinois 60120-3090
(312) 697-2260 • Telex 72-2416 • Cable SIMELCO
IN CANADA: Bach-Simpson, Ltd., London, Ontario
IN ENGLAND: Bach-Simpson (U.K.) Ltd., Wadebridge, Cornwall

Warranty

SIMPSON ELECTRIC COMPANY warrants each instrument and other articles of equipment manufactured by it to be free from defects in material and workmanship under normal use and service, its obligation under this warranty being limited to making good at its factory any instrument or other article of equipment which shall within 90 days after delivery of such instrument or other article of equipment to the original purchaser be returned intact to it, or to one of its authorized service stations, with transportation charges prepaid, and which its examination shall disclose to its satisfaction to have been thus defective; this warranty being expressly in lieu of all other warranties expressed or implied and of all other obligations or liabilities on its part, and SIMPSON ELECTRIC COMPANY neither assumes nor authorizes any other persons to assume for it any other liability in connection with the sale of its products.

This warranty shall not apply to any instrument or other article of equipment which shall have been repaired or altered outside the SIMPSON ELECTRIC COMPANY factory or authorized service stations, nor which has been subject to misuse, negligence or accident, incorrect wiring by others, or installation or use not in accord with instructions furnished by the manufacturer.

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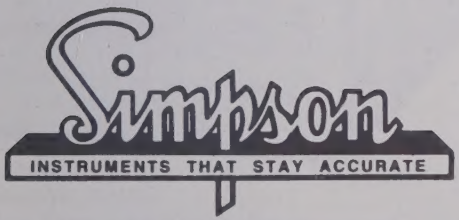

Printed in U.S.A.
Effective Date: 0787
(123.05)
Edition: 6th

Part No. 6-111701

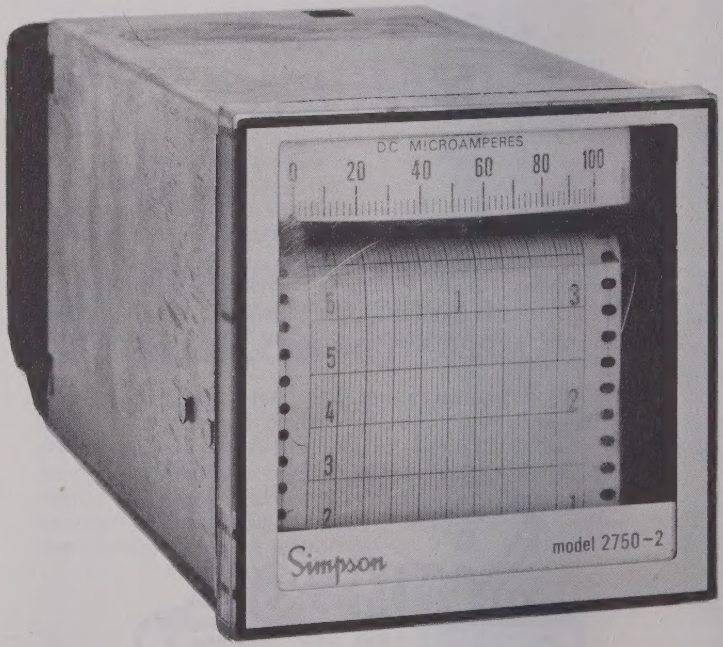

Figure 1-1. 2750-2 Strip Chart Recorder

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NOTE: This Operator's Manual contains information essential to the operation of this Instrument. Therefore, it should be kept in a convenient place and used for reference as required.

SAFETY SYMBOLS AND MARKINGS

Symbols and special markings are used in this manual and/or on the Instrument to call attention to possible hazards that may occur in the operation of the instrument. For personal protection, the operator must recognize the symbols and markings and observe the instructions to which they refer. These symbols and markings are defined below.

WARNING

This paragraph heading calls attention to a procedure, practice or the like which, if not correctly performed or adhered to, could result in personal injury.

CAUTION

This paragraph heading calls attention to a procedure practice or the like which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the instrument.

This symbol (a red lightning flash) calls attention to nearby parts at which a shock hazard may or does exist. These parts must not be touched while energized.

This symbol appears next to a protective grounding terminal which must be connected to earth ground before any other connections are made or the equipment operated.

This marking adjacent to a terminal, operating device or another marking instructs the operator to refer to an explanation in the operator's manual to avoid damage to the equipment or personal injury.

WARNING

This Instrument is designed to prevent accidental shock to the operator when properly used. However, no engineering design can render safe an instrument which is used carelessly. Therefore, this manual must be read carefully and completely prior to making any measurements. Failure to follow directions can result in a serious or fatal accident.

SHOCK HAZARD: As defined in American National Standard, C39.5, Safety Requirements for Electrical & Electronic Measuring & Controlling Instrumentation, a shock hazard shall be considered to exist at any part involving a potential in excess of 30 volts r.m.s. (sinewave) or 42.4 VDC or peak, and where a leakage current from that part to ground exceeds 0.5 milliampere, when measured with an appropriate measuring instrument defined in Section 11.6.1 of ANSI C39.5.

NOTE: The proper measuring instrument for the measurement of leakage current consists essentially of a network of a 1500 ohm non-inductive resistor shunted by a 0.15 microfarad capacitor connected between the terminals of the measuring instrument. The leakage current is that portion of the current that flows through the resistor. The Simpson Model 229-Series 2 AC Leakage Current Tester meets the ANSI C39.5 requirements for the measurement of AC leakage current and can be used for this purpose. To measure DC leakage current, connect a 1500 ohm non-inductive resistor in series with a Simpson 0-500 DC microammeter and use this as the measuring instrument.

SECTION I
INTRODUCTION

1.1 GENERAL

1.1.1 The Simpson 2750-2 (hereafter referred to as the 2750-2 or the Instrument) is a compact panel-mounted clamping-type strip chart recorder, which provides a recording by making a series of sequential impressions on pressure-sensitive chart paper.

1.1.2 The measured input to the pivot and jewel meter movement is converted to proportional pointer positions on the meter scale above the chart paper. Every 12, 6 or 2 seconds, depending upon the selected speed, a chopper bar momentarily clamps the pointer against the pressure sensitive chart paper. This produces a black dot. The chart paper is simultaneously advanced by the chopper bar ratchet and the black dots combine to form an apparent continuous line or curve, following changes in the input. The movement pointer is free to follow input changes at all times other than during the momentary clamping period.

1.1.3 The specially formulated chart paper produces a clean, clear trace and does not smudge, fog or blur with age. This system eliminates clogging, skipping and blotting problems associated with ordinary pen and ink recording systems.

1.1.4 The 2750-2 is available either as an A.C., 60 Hz line powered Instrument (50 Hz units are available on special order) or as a D.C. powered Instrument. The DC powered Instrument operates from an external 7-15 V DC source or can be operated from internal 9 V batteries. Accessory adapters are available to operate the DC units from 24 V or 48 V DC sources. Operation from internal batteries may be found useful where common-mode problems exist.

1.1.5 The recorder chassis slides out of the front of the unit (after the plastic cover is removed). As it does so, all external circuits are automatically disconnected from the chassis by an internal connector block. This assures protection against electric shock while servicing the chassis and eliminates the need for operator access to the rear panel connections and shock hazards that may exist behind the panel. All normal maintenance work such as zero adjustment of the meter, replacement of chart paper or changing of chart speed can be performed by partial withdrawal or removal of the chassis from the front of the panel.

1.1.6 The 2750-2 is intended for panel mounting in an enclosure that makes the rear panel connections inaccessible to the operator and with the rear panel protective grounding screw marked ⏚ solidly connected to earth ground. These requirements are necessary for the protection of the operator against electric shock and must be observed.

1.1.7 24 V OR 48 V DC ADAPTERS

Accessory adapters are available to enable operating the DC powered 2750-2 from 24 V or 48 V DC sources. An adapter consists of a resistive voltage divider with a capacitor across the output. The capacitor serves to stabilize the output voltage of the adapter by providing the momentary surge current required to operate the clamping bar relay. Refer to Fig. 2-7 for circuit details and Table 1-3 for catalog numbers of the adapters.

1.1.8 The 2750-2 can be made available with a case extender that provides room for an amplifier input circuit for low current ranges or for expanded scale voltmeter circuits. Refer to Fig. 1-3 and Table 1-4 for catalog numbers and ranges available.

1.2 SAFETY CONSIDERATIONS

This Operator's Manual contains special caution and warning headings which alert the user to hazardous operating and servicing conditions. These CAUTION or WARNING headings appear throughout this publication, where applicable, and are defined at the front of the manual under SAFETY SYMBOLS. To ensure the safety of operating and servicing personnel and to retain the operating performance of this Instrument, these instructions must be adhered to.

1.3 TECHNICAL DATA

Table 1-1 lists the Technical Specifications for the 2750-2.

TABLE 1-1. TECHNICAL DATA

1. MOVEMENT:

TYPE:	Pivot and jewel
RESPONSE TIME:	< 2 seconds
SCALE LENGTH:	60 mm

2. CHART PAPER:

TYPE:	Pressure sensitive, hard wax coating
LENGTH:	52 ft. (16 meters)
WIDTH:	2.75″ (70 mm)
RECORDING WIDTH:	2.16″ (55 mm)

3. CHART SPEEDS & CAPACITY: (60 mm/h is standard)

CAM (AC UNITS) or JUMPER (DC UNITS)	CHART SPEED mm/h	in./h	Scale divisions	IMPRESSION RATE	CAPACITY Hours	Days
10 mm/h	10	.39	1/h	5/min	1600	66
20 mm/h	20	.79	2/h	10/min	800	33
60 mm/h	60	2.36	6/h	30/min	266	11

4. CHART, TIME MARKINGS (1-24h):

CHART SPEED	MARKING
10 mm/h	on left side of chart
20 mm/h	on right side of chart
60 mm/h	in center of chart

5. 30 mm INDEX MARK:

CHART SPEED	IMPRESSION OCCURRED
10 mm/h	3 h before index mark
20 mm/h	1½ h before index mark
60 mm/h	½ h before index mark

6. RECORDING ACCURACY: ±1.5% of F.S.

7. TEMPERATURE:

OPERATING:	32 to 104°F (0° to 40°C)
REFERENCE:	73.4°F ±1°F (23°C) at 30-60% R.H.

8. POWER REQUIREMENTS:

AC POWERED UNITS: 120/240 V ±10%, 60 Hz, 1.6/3.2 VA

DC POWERED UNITS: 7-15 V DC external supply, 9 V internal battery or 24 or 48 V DC external supply with accessory adapters

NOTE: 120/240 V, 50 Hz units available on special order.

9. MAX. RATED CIRCUIT-TO-GROUND VOLTAGE:*

All units with case grounded: 250 V rms or 350 V DC.

10. DIMENSIONS:

FRONT PANEL..... 3.78 x 3.78″ (96 mm x 96 mm)
OVERALL DEPTH
(INCL. TERMINALS)..... 7.5″ (19.0 cm)
DEPTH BEHIND PANEL
(INCL. TERMINALS) .... 7.1″ (18.0 cm)
PANEL OPENING
REQUIRED ..... 3.62 x 3.62″ (92 mm x 92 mm)

11. WEIGHT ..... 2.9 lbs. (1.3 kg)

12. REAR PANEL TERMINALS ..... Male quick-connect, ¼″ tab

*The maximum voltage, with respect to earth ground, which may be safely applied to the circuits of the Instrument.

TABLE 1-2. ACCESSORIES FURNISHED WITH THIS INSTRUMENT

QUANTITY	ITEM	CATALOG
2	Rolls of chart paper	22155 or 22156, as applicable. Refer to Table 1-3.
1 set (of 3)	Chart speed cams (AC line operated units only) one cam installed in unit.	(See Table 7-1)

TABLE 1-3. CHART PAPER AND ADAPTER CATALOG NO.

ITEM	CATALOG NO.
Chart paper roll**, 50 Divisions wide	22155
Chart paper roll**, 30 Divisions wide	22156
48 V adapter for DC powered units	22150
24 V adapter for DC powered units	22151
BATTERIES (DC POWERED UNITS)	
9 V Neda 1604 A, Alkaline (2 required)	Readily available in local stores

**Special, hard wax coating, 16 m long, 70 mm wide

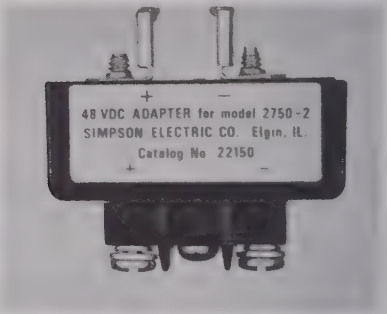


Fig. 1-2. 2750-2 24 and 48 V DC Adapter

TABLE 1-4. EXTENDED RANGES AVAILABLE

RANGE	CATALOG NO.
0-10 DC μA	D22130
0-50 DC μA	D22131
0-100 DC μA	D22132
100-130 AC V	D22143

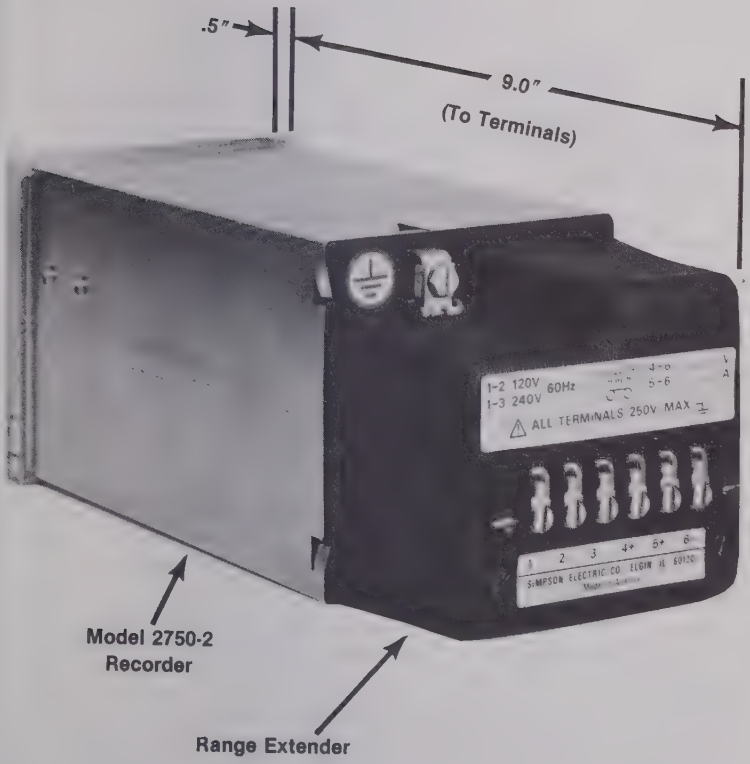


Fig. 1-3. 2750-2 With Range Extender (Rear View)

SECTION II
INSTALLATION

2.1 GENERAL

2.1.1 This section contains instructions for the receiving and installation of the 2750-2. Included are unpacking, inspection, warranty and shipping procedures, power source requirements and installation instructions.

2.2 UNPACKING AND INSPECTION

2.2.1 Examine the shipping carton for obvious signs of damage. Inspect the Instrument for possible damage incurred during shipment. If damage is noted, notify the carrier and supplier and do not use the Instrument. If Instrument appears to be in good condition, read Operator's Manual in its entirety. Become familiar with the Instrument as instructed in the manual, then proceed to check the electrical performance as soon as possible. Also, check that all items are included with the Instrument (Table 1-2).

2.2.2 Save the shipping carton and packing materials for future storing or shipping of the Instrument.

2.3 WARRANTY

2.3.1 The Simpson Electric Company warranty policy is printed on the inside front cover of this manual. Read it carefully prior to requesting a warranty repair.

NOTE: For assistance of any kind, including help with the Instrument under warranty, contact the nearest Authorized Service Center for instructions (listed on the last pages of this manual). If it is necessary to contact the factory directly, give full details of any difficulty and include the Instrument model number, serial number and date of purchase. Service data will be mailed promptly. If an estimate of charges for non-warranty or other service work is required, a maximum charge estimate will be quoted. This charge will not be exceeded without prior approval. (As an added convenience a record sheet has been included with this manual for noting all repair and servicing functions. See the back of this manual.)

2.4 SHIPPING

2.4.1 Pack the Instrument carefully and ship it prepaid and insured to the proper destination.

2.5 INSTALLATION

WARNING

This instrument is intended for panel mounting in an enclosure that makes the rear panel connections inaccessible to the operator and with the rear panel protective grounding screw marked ⏚ solidly connected to earth ground. The unit is not to be operated until so enclosed and grounded.

2.5.1 The 2750-2 is designed to be installed in a vertical panel (front cover vertical, chassis horizontal). This position ensures proper functioning and accuracy of the recording mechanism.

2.5.2 Dimensional diagram

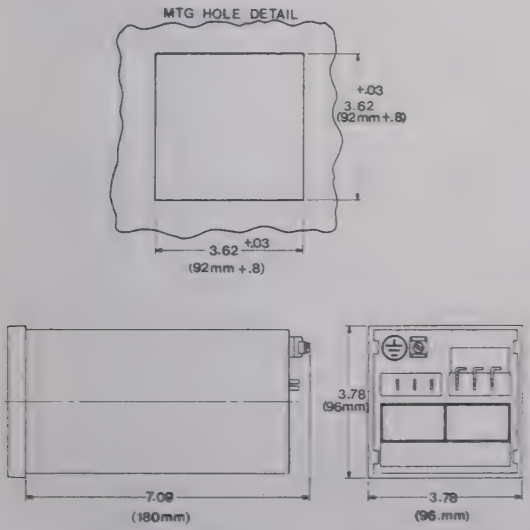
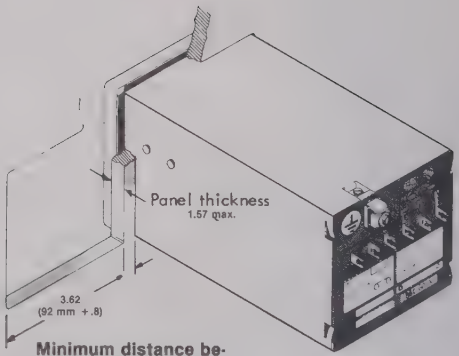


Fig. 2-1. Dimensional Diagram

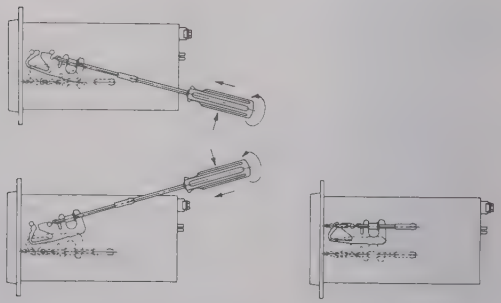


Minimum distance between adjoining instruments .187 (whereby the bezels are adjacent)

Fig. 2-2. Installing 2750-2 Into Panel

CAUTION

Do not twist the case when installing it within the panel. Inadvertent twisting can cause the meter clamping bar to bind.



Place fastener around the back cones, push fastener over front, and screw firmly against the panel.

Fig. 2-3. Installation of Mounting Bracket

2.5.3 Place recorder into position in the panel cut-out.

2.5.4 Attach the mounting brackets (1 ea. left and right side) to the mounting cones on both sides of the recorder. Holding the flat side of the bracket against the case beneath the cones and with notches upward and screwdriver slot toward rear, slide the center notch under the rim of the rear cone. Refer to Fig. 2-2. Holding the bracket firmly against the rear cone, rotate the bracket until the front cone snaps into the notch at the front end of the bracket.

2.5.5 Insert a 3/16″ flat-blade screwdriver into the fittings at the rear end of the screws and tighten the screws against the panel to secure the recorder.

2.6 POWER SOURCE REQUIREMENTS

2.6.1 AC LINE POWERED UNITS. These units may be operated either from 120 V AC or 240 V AC by proper selection of terminals on the rear of the case.

OPERATING VOLTAGE	VA
120 V AC	1.6
240 V AC	3.2

2.6.2 DC POWERED UNITS. These units may be operated from an external source of 7-15 V DC, from an external source of 24 V or 48 V DC by means of adapters (see para. 1.1.7), or from internal 9 V batteries (two in parallel). The source of supply for 7-15 V DC operation must be capable of delivering the momentary surge current required for recording (clamping). The 24 V and 48 V adapters utilize a capacitor to reduce the surge load on the supply.

TABLE 2-1. OPERATING CURRENT

OPERATING VOLTAGE	MEASURING (Steady)	RECORDING (Momentary)
7-15 V DC	.1 - .8 mA	150-270 mA
24 V DC (adapter)	17 mA	22 mA
48 V DC (adapter)	17 mA	19 mA
Internal 9 V battery	.14 mA	160 mA

2.6.3 ELECTRICAL CONNECTIONS

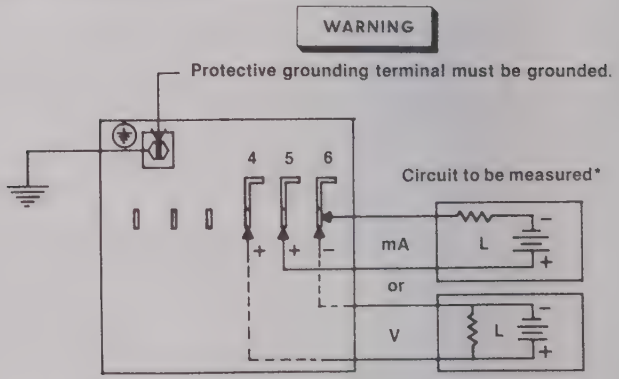


Fig. 2-4. Measuring Connections for All Units.

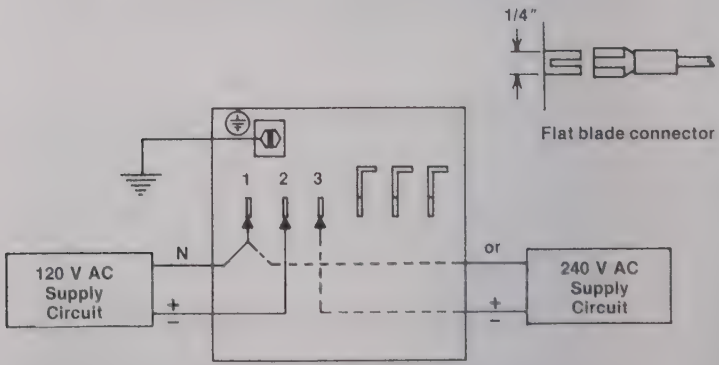


Fig. 2-5. AC Powered (External Supply)

* ! ALL TERMINALS 250 V MAX

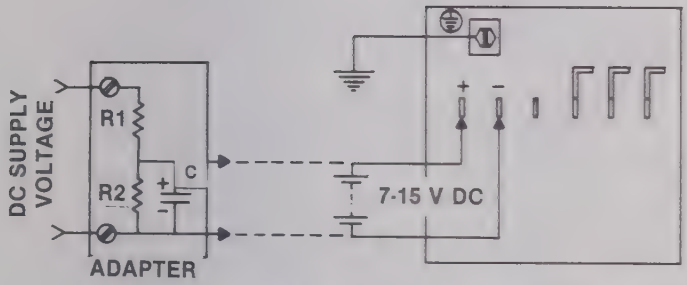


Fig. 2-6. DC Powered Unit (External Supply)

TABLE 2-2. ADAPTER DATA

Catalog No.	Supply Volts	R1	R2	C
22150	48 V	2.21 KΩ	700 Ω	475 μf 25 V
22151	24 V	760 Ω		

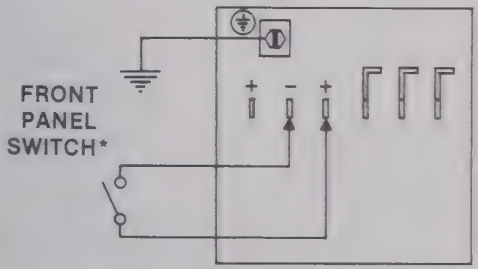


Fig. 2-7. DC Powered Unit (Internal Battery Supply)

WARNING

*When operating from internal 9 V batteries, the jumper must be connected or disconnected to start or stop the recorder. To do this, access to the interior of the enclosure (behind the panel) is required. Shock hazards may exist within the enclosure. To avoid electric shock to the operator, a front panel mounted switch in series with the jumper (Fig. 2-7) should be provided to permit the operator to start and stop the recorder.

SECTION III
CONTROLS AND INDICATORS

3.1 GENERAL: All components required to operate the recorder are identified and described in Table 3-1. Become thoroughly familiar with them before attempting to operate the recorder.

TABLE 3-1. CONTROLS AND INDICATORS

Fig.		
3-1	**Front Panel, Cover Removed**	
	1. Time mark 30 :	This mark, adjacent to the chart on both sides, is located 30 mm (3 scale divisions on the chart) from the point at which the impressions are being made on the chart.
	2. Front cover:	The transparent cover permits viewing the recorder chart while protecting the mechanism from dust and damage.
	3. Cover removing grips:	The fluted area is the gripping area for removal of the cover.
	4. Locking lever:	This lever, when moved to the right, allows the chassis to be pulled out far enough for chart servicing.
	5. Panel mounting cones:	The panel mounting brackets attach to these cones to hold the recorder to the panel.
3-2	**Chassis Withdrawn to Stop, Right Side**	
	6. Meter zero adjust screw:	This screw is used for mechanical zero adjustment of the meter pointer.

Fig.

7. Interlock release lever: This lever stops the chassis from being completely removed. The chassis may be removed by inserting a pointed object into the slot and lifting the lever to release the chassis.

3-3 Chassis Withdrawn, Chart Drive Mechanism Opened

8. Battery Compartment (DC powered units): Compartment for two 9 V batteries for self-contained power source.

9. Pointer and meter scale: The pointer indicates the instantaneous value of voltage or current at the measuring terminals on the meter scale.

10. Finger grips: The grips provide convenient means of pulling the chassis from the case.

11. Chart supply roll: The chart supply roll stores in a compartment behind the take-up spool (16).

12. Chart paper guide roller: Provides the tension required to hold the chart paper perforations securely to the chart drive roller.

13. Chart drive roller: The roller engages the perforations along the edge of the chart paper and advances the chart by gearing from the chopper bar ratchet gear.

14. Chart paper perforations: The perforations on the left side of the chart are fitted over teeth on the chart drive roller to advance the chart.

15. Finger grips: These grips are used to release and swing down the chart mechanism for chart replacement.

16. Take-up spool: This spool is belt driven from the chart drive roller to store the used chart paper.

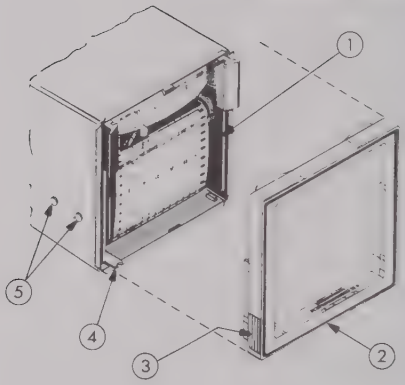


Fig. 3-1.
Front Panel,
Cover Removed

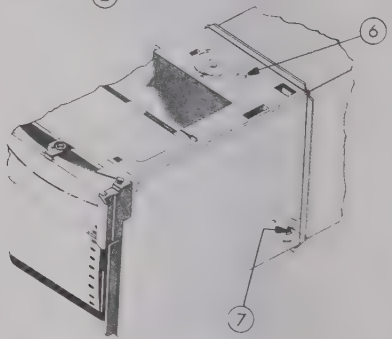


Fig. 3-2.
Chassis Withdrawn
to Stop, Right Side

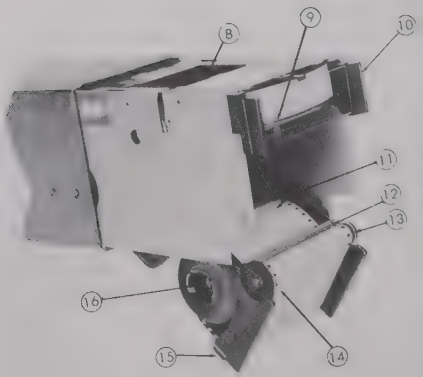


Fig. 3-3.
Chassis Withdrawn,
Chart Drive Mechanism
Opened

Fig.		
3-4	**Rear Panel (AC Line powered unit shown)**	
	17. Protective grounding terminal:	This terminal is connected to earth ground for protection against electric shock.
	18. Measuring terminals:	These terminals are connected to the circuit to be measured.
	19. Power input terminals:	These terminals are connected to the source of power required to operate the recording mechanism.
3-5	**Chart Speed Cam (AC powered units)**	
	20. Cam retaining nut:	This nut is removed to change cams.
	21. Chart speed cam (AC line powered units):	The number of tabs on this cam sets the chart speed and impression rate.

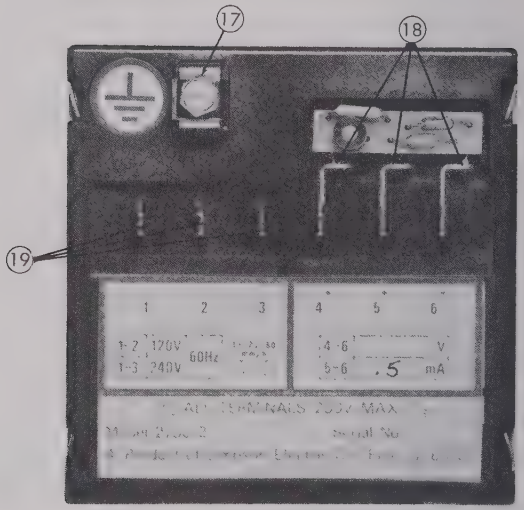


Fig. 3-4. Rear Panel (AC Line Powered Unit Shown)

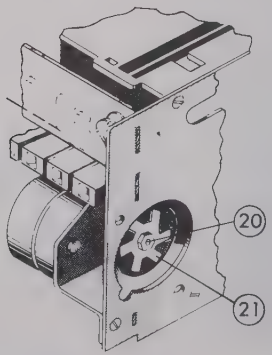


Fig. 3-5. Chart Speed Cam (AC Line Powered Units)

SECTION IV
OPERATION

4.1 GENERAL

4.1.1 This section of the manual provides instructions for the normal operation and maintenance of the 2750-2. Circled numbers in text refer to components described in Table 3-1 in Section III.

WARNING

Before proceeding with the operation of the 2750-2, review the Shock Hazard definition at the front of this manual.

4.2 SAFETY PRECAUTIONS

4.2.1 This section of the manual contains all the information related to the operation of the 2750-2. Special notes and instructions have also been provided for added safety and convenience.

WARNING

Ground the Instrument case before connecting to powerline. This connection must be made using the ground screw terminal (17) (Figure 3-4) securely connected to an earth (powerline) ground.

4.3 REMOVAL OF UNIT FOR CHASSIS ACCESS

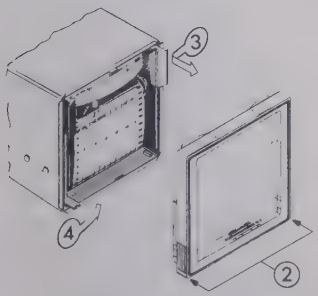


Fig. 4-1. Cover Removed

1. Grasp fluted areas at bottom of cover (2) and pull outward to unlatch cover. Disengage retaining ears from top of case and remove cover.
2. Hold locking lever (4) to the right to release the chassis.
3. Grasp the finger grips (3) on either side of the metal scale and pull chassis out until it latches in the fully withdrawn position.

4. To close the unit, move the locking lever (4) to the right to release the latch and push the chassis fully in until the latch is heard to re-engage.
5. Position the ears at the top of the cover between the case and the top of the meter scale and push inward at the bottom of the cover until it snaps into place.

4.4 REMOVAL OF CHASSIS FROM CASE

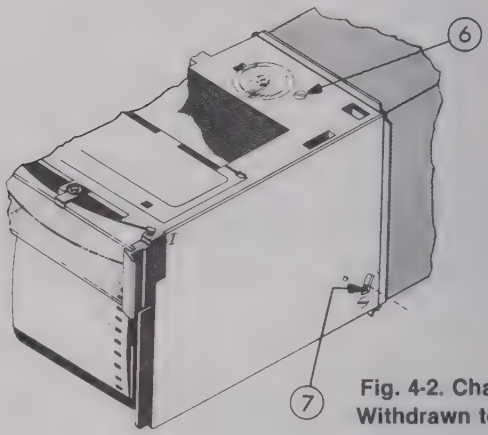


Fig. 4-2. Chassis Withdrawn to Stop

1. Withdraw chassis from case in accordance with steps 1 thru 3 in paragraph 4.3 above.
2. The chassis interlock (7) lever can be seen behind the slot on the right side of the chassis.
3. Insert a pointed object into the bottom of the slot (Fig. 4-2) and lift the lever to release the interlock while pulling outward on the chassis assembly.
4. To replace the chassis into the case, hold it in the proper position and push it in. It will immediately latch at the fully withdrawn position.
5. To close the unit follow steps 4 and 5 in paragraph 4.3 above.

4.5 INSTALLING OR REPLACING CHARTS

1. (Refer to Fig. 3-3.)
2. Withdraw the chassis in accordance with instructions in paragraph 4.3.
3. Grasp the grips (15), squeeze them to unlatch the drive mechanism and pull downward.
4. Remove the empty cardboard reel, if any, and place the chart roll (11) behind the take-up spool (16) with the round perforations to the left.
5. Pass the end of the chart paper under the guide roller (12) and pull out about 8″ of paper.
6. Position the round perforations over the drive roller (13) teeth, pass the chart down past the viewing area and insert the remaining chart between the two blades of the take-up spool (16). Enough chart must protrude beyond the take-up spool to fold back over one blade to secure the chart to the spool.
7. Rotate the chart drive spool gear to move the chart downward until certain that the take-up spool has secured the end of the chart and the chart paper is stretched taut.
8. Continue rotating the chart drive spool until the appropriate time marking (left, center or right side of the chart) is aligned with the chart impression point. The impression point is not visible with the unit closed nor can it be accurately located with the chart drive mechanism open. The impression point can be located by means of the "30" time mark (5), index line. (See Fig. 4-3). The index line on either side of the chart viewing area is located 30 mm from the impression point which is equivalent to 1/2 hour (@ 60 mm/h), 1-1/2 hour (@ 20 mm/h), or 3 hours (@ 10 mm/h).
9. Tilt the chart drive unit upward until it latches in place and push the chassis back into the case (paragraph 4.2) to begin recording.

4.6 MECHANICAL ZERO ADJUSTMENT

1. To check mechanical zero of the meter movement, withdraw the chassis from the case (paragraph 4.2). This will deenergize the circuit.

2. Note whether the meter pointer (9) indicates exactly zero on the meter scale. If it does, re-close the unit. If not, proceed as follows.
3. Locate the white-plastic adjusting screw (6) on the top of the chassis toward the rear.
4. Rotate this screw slightly in either direction as required to move the pointer to zero while gently tapping the top of the chassis to eliminate hysteresis effects.
5. Re-close the unit (paragraph 4.3).

4.7 CHANGING CHART SPEED

4.7.1 All Units: Remove the chassis from the case (paragraph 4.2 and 4.3).

4.7.2 AC Line Powered Units

1. Remove the plastic nut (20) which secures the chart drive cam (21) (60 mm/h) and lift off the cam. (Refer to Fig. 3-5)
2. Place new cam (10 or 20 mm/h) over shaft with the arrow facing outward and the index hole fitted to the index pin on the shaft hub. The clamping bar lever may have to be held out of the way while fitting the cam. Do not attempt to rotate the motor shaft.
3. Replace and tighten the platic nut. Avoid excessive force.
4. Replace unit into case (paragraph 4.2 and 4.3).

4.7.3 DC Powered Units

1. Locate the three pins marked 10, 20, 60 on the rear-of-chassis circuit board just below the terminal strip. A short jumper lead is connected to one of the pins.
2. Disconnect the jumper from its pin and reconnect it to the pin that provides the desired chart speed (10, 20 or 60 mm/h).
3. Replace unit into its case (paragraph 4.2 and 4.3).

4.8 READING THE CHART

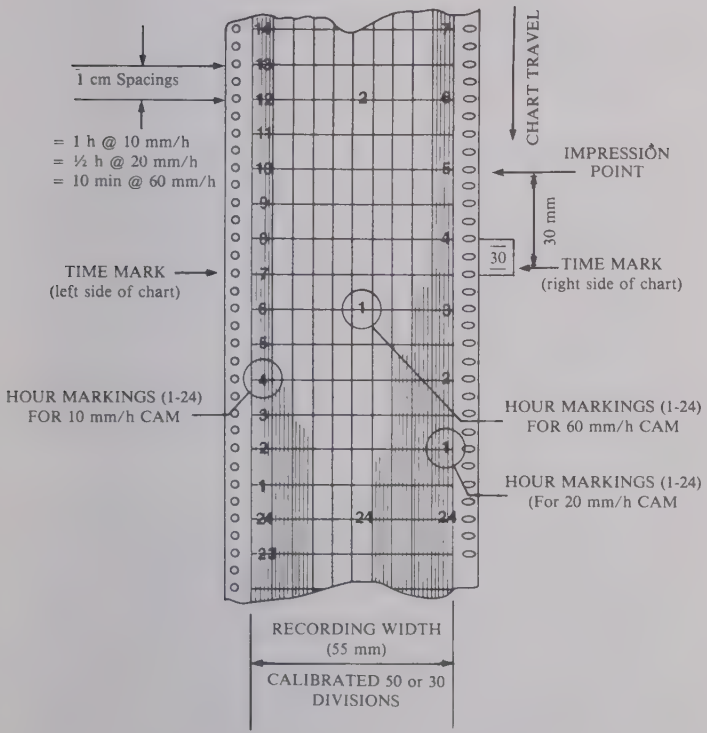


FIG. 4-3. Chart Paper

SECTION V
THEORY OF OPERATION

5.1 GENERAL

5.1.1 Rear panel terminals pass directly through the case to an internal connector which serves to deenergize all internal circuitry when the recorder chassis is withdrawn from the front of the case. This eliminates any shock hazard to the operator while performing maintenance functions.

5.2 MEASURING SYSTEM

5.2.1 The parameter to be measured connects to a circuit board at the rear of the recorder chassis where it is modified as required to match the characteristics of the meter movement (range and function).

5.2.2 A red arrow at the end of the meter pointer indicates the instantaneous deflection of the pointer on the calibrated meter scale. The pointer shaft passes over the chart paper directly above the chart drive roller where periodically it is pressed down against the special wax-coated chart by the clamping bar to make an impression on the chart.

5.3 CHART DRIVE SYSTEM

5.3.1 AC Line Powered Units: A special notched cam attached to the shaft of a synchronous electric motor moves a lever system which moves the clamping bar down to press the meter pointer against the chart paper. A ratchet pawl attached to the lever simultaneously rotates a ratchet gear by one tooth. The ratchet gear drives the chart drive roller through a gear train to advance the chart slightly each time an impression is made. The chart drive roller is belted to the take-up spool which stores the used-up chart.

5.3.2 DC Powered Units: The DC powered units are not motor driven. The clamping bar is operated by means of an electromechanical relay. The impression rate is provided by a quartz controlled oscillator and frequency divider which produces a selectable pulse rate. The pulse rate selected determines the chart speed and impression rate. At each pulse, the relay presses the chopper bar against the meter pointer to record a dot on the chart and also advance the chart.

The DC units will operate satisfactorily over a supply voltage range of 7-15 V. Adapters to operate the units from 24 or 48 V DC supplies are available as accessories.

With internal 9 V battery operation, the two 9 V batteries are in parallel and provide sufficient recording time for one chart roll.

5.4 CHART PAPER

5.4.1 The chart paper consists of a specially formulated, white, hard-wax coating over a black paper roll. As the meter pointer is pressed against the curved surface of the chart, the white coating is displaced to permit the black background to show through as a black dot. The chart trace consists of a series of closely spaced black dots which appear as a continuous line or curve. The wax chart system eliminates the many maintenance problems inherent with inking pen systems. (See Fig. 4-3)

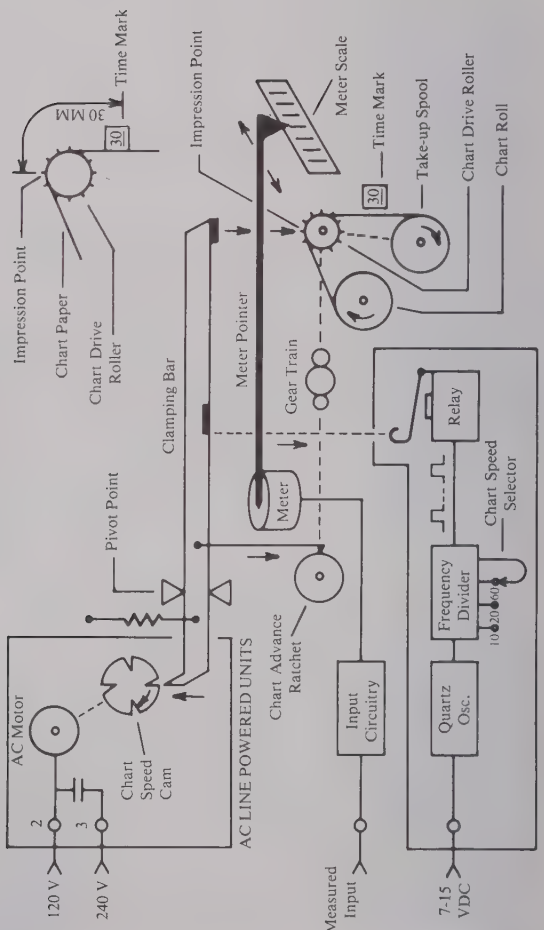


Fig. 5-1. System Functional Diagram

SECTION VI
OPERATOR MAINTENANCE

6.1 GENERAL: Operator maintenance of the 2750-2 is minimal. Other than routine changing of chart rolls, maintenance may call for occasional brushing-out of accumulated wax particles from the case and/or cleaning the front cover. Any requirements beyond these should be referred to qualified service personnel (refer to Section VII).

WARNING

With the recorder chassis completely removed, the terminal pins inside the case at the rear are accessible and a shock hazard may exist. Before attempting to reach inside the case with hand or tool, make certain that all power sources to the equipment have been deenergized.

6.2 CLEANING THE FRONT COVER. Wash the cover in mild detergent-water mixture, rinse in clean water and dry carefully with a soft cloth to avoid scratching the viewing area. Do not use chemical solvents on plastic parts.

6.3 ANNUAL CARE. It is recommended that the Instrument be returned to the nearest Authorized Service Center (listing on back pages of this manual) at least once yearly (sooner, if required) for a complete check-up, adjustment and calibration.

6.4 STORAGE. Instruments removed from service should be stored in their original shipping container for protection. Instruments should be stored in a location free of temperature and humidity extremes, dust, corrosive fumes, vibration or shock.

Remove internal batteries, if any, if storage time may exceed 30 days.

WARNING

The following servicing instructions for 2750-2 (Section VII) and for 2760-2 (Section XIII) are for use by qualified personnel only. To avoid electrical shock, do not perform any servicing other than that contained in the operating instructions unless you are qualified to do so.

SECTION VII
SERVICING INSTRUCTIONS

7.1 GENERAL

It is important to the performance of the Instrument and to the safety of the operator that repair work is performed properly using the correct replacement parts. For this reason all servicing other than as described in the operating instructions must be performed by qualified service personnel. It is recommended that any such servicing be referred to an Authorized Service Center (See listing following this section.)

7.2 REPLACEMENT PARTS

Table 7-1 lists those replacement parts most likely to be required in the operation of the unit and which may be replaced by the operator. For parts not listed herein, contact your nearest Authorized Service Center or the factory Service Department in Elgin, Illinois.

Table 7-1 Replacement Parts

Description	Part No.
Chart Speed Cam, 60 mm/h	GO-001085
Chart Speed Cam, 20 mm/h	GO-001071
Chart Speed Cam, 10 mm/h	GO-001070
Nylon Nut	GO-001120
Plastic Front Cover	GO-001087

SECTION VIII

INTRODUCTION 2760-2 RECORDER

8.1 GENERAL

The Simpson 2760-2 Temperature Recorder (hereafter referred to as the 2760-2 or "the Instrument") is a compact panel mounted, clamping type strip chart recorder, which provides a recording by making a series of sequential impressions on pressure sensitive chart paper. The 2760-2 is available only as an AC powered instrument.

8.2 TECHNICAL DATA

Table 8-1 lists the Technical Specifications for the 2760-2 that differ from those of the 2750-2 listed in Section I of the manual.

TABLE 8-1. TECHNICAL DATA

1. TEMPERATURE:	A wide choice of standard temperature ranges is available, depending on the recorder ordered. (For special ranges, chart paper, sensors, etc., contact the Simpson factory in Elgin, Ill.)
OPERATING:	−10 °C to +40 °C (+14 °F to +104 °F)
REFERENCE:	23° ±1 °C @ 30 to 60% RH. (73.4° ±1.8 °F)
2. SENSOR TYPES:	
a. Iron Constantan Thermocouple:	For temperature ranges from +20 °C to +600 °C (+68 °F to +1112 °F)
b. Chromel-Alumel Thermocouple:	For temperature ranges from +20 °C to +1200 °C (+68 °F to +2192 °F)
3. COLD JUNCTION: Compensation: (thermocouple sensor)	Effect of ambient temperature is less than 1% of the incremental span within the operating temperature range; negligible error between +20 °C and +30 °C (+68 °F and +86 °F).

4. POWER REQUIREMENTS:

Standard power input: 120/240 VAC ±10%, 60 Hz
1.6/3.2 VA

(120/240 VAC, 50 Hz units available on special order.)

DIMENSIONS:

FRONT PANEL .....3.78″ x 3.78″ (96m x 96mm)
DEPTH BEHIND PANEL
(INCL. TERMINALS) .9.1″ (231mm)
PANEL OPENING
REQUIRED .....3.62″ x 3.62″ (92mm x 92mm)
WEIGHT .....3.7 lbs. (1.7 kg)
REAR PANEL
TERMINALS .....Terminal block type

TABLE 8-2. ACCESSORIES FURNISHED WITH THIS INSTRUMENT

QUANTITY	ITEM	CATALOG NO.
2	Rolls of chart paper	As applicable. Refer to Table 8-3.
1 set of 3	Chart speed cams. One cam installed in unit	(See Table 7-1.)

TABLE 8-3. CHART PAPER

CAT. NO.	TYPE OF SENSOR	TEMPERATURE SPAN
23261	I/C (Iron-Constantan)	−50°F to +250°F (−45.56°C to +121.1°C)
23262	I/C " "	0° to +300°F (−7.78°C to +148.89°C)
23263	I/C " "	0° to +500°F (−7.78°C to +260°C)
23264	I/C " "	0° to +800°F (−7.78°C to +426.67°C)
23265	C/A (Chromel-Alumel)	0° to +1500°F (−7.78°C to +815.56°C)
23266	C/A " "	0° to +2500°F (−7.78°C to +1371.1°C)

SECTION IX
CONTROLS AND INDICATORS 2760-2 RECORDER

9.1 GENERAL

All components required to operate the Instrument are identified and described in Section III of the manual and the following table:

TABLE 9-1. CONTROLS AND INDICATORS

NOTE: Item number in Table 9-1 corresponds with call-outs in Figure 9-1.

ITEM	DESCRIPTION
1. Protective grounding terminal:	This terminal is connected to earth ground for protection against electric shock.
2. Sensor terminals:	These terminals are used for connecting the sensor to the internal measurement circuits according to the type of sensor used.
3. Power input terminals:	These terminals are connected to the source of power required to operate the recording mechanism.

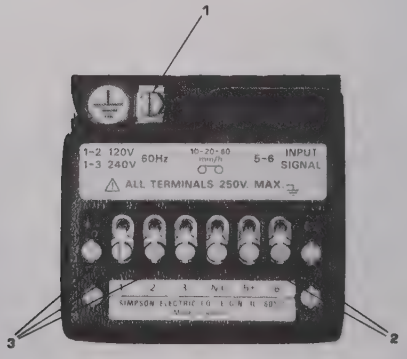


Fig. 9-1. Rear Panel 2760-2.

SECTION X
OPERATION 2760-2 RECORDER

10.1 GENERAL

WARNING

Before proceeding with the operation of the 2760-2, review the shock hazard definition at the front of the 2750-2 Operator's Manual.

10.2 INITIAL CONNECTIONS, CONTROL SETTINGS AND PREPARATIONS

10.2.1 Perform the following connections, control settings, and make the necessary preparations prior to making temperature measurements.

a. Review the instructions on paragraphs 4.2 thru 4.7.

b. Select the sensor. The sensor type is indicated by the symbol in the upper left corner of the dial. The symbol will be "C/A" for Chromel-Alumel, "I/C" for Iron Constantan.

CAUTION

Do not overtighten the screws in the following step.

c. Determine terminals to be used for connecting the sensor. Loosen the screws on these terminals. Strip about ½ inch of insulation from the ends of the sensor leads. Wrap the stripped end(s) around the body of the screw(s) and tighten snugly.

d. Select the chart speed to be used (paragraph 4.7) and the appropriate gear unit.

e. Install the chart paper (Table 8-3) that matches the selected speed, temperature range and thermocouple type.

10.3 TEMPERATURE MEASUREMENT

WARNING

Prior to making measurements, review Section X. Do not operate the Instrument without the front cover being in place.

10.3.1 Thermocouple sensors. Check that the thermocouple used is the same type as marked on the upper left corner of the dial.

10.3.2 Prior to performing temperature measurements, read the following:

CAUTION

Do not make measurements in acids, etc., or under environmental conditions which could attack the sensor assembly.

a. Make the best possible thermal contact between the sensor and the area where the temperature is to be measured.

b. When measuring air or gas temperature, allow several minutes for the sensor temperature to stabilize.

SECTION XI
THEORY OF OPERATION 2760-2 RECORDER

11.1 GENERAL

This section, as a supplement to Section V of the manual, describes the theory of operation of the 2760-2. Figure 11-1 shows the overall system block diagram of the Instrument.

11.2 OVERALL MEASUREMENT SYSTEM

11.2.1 The output of the DC regulated power supply provides a stable DC voltage source for the measuring circuit.

11.2.2 The measuring circuit consists of a sensor, a bridge circuit and a dual amplifier.

11.2.3 The bridge circuit provides a differential voltage to the input of the amplifier and a cold junction compensation resistor within the bridge provides compensation for the changes of ambient temperature.

11.2.4 Regardless of the type sensor, the output of the measuring circuit is a function of the temperature at the sensor and provides the "drive" for the meter circuit.

11.2.5 The input into the meter movement causes the moving coil assembly to deflect. This deflection may be observed visually with reference to the pointer and the printed scale.

11.2.6 The meter deflection also positions the pointer in the proper position over the recorder chart paper, to provide (after clamping) a recording of the measured parameter.

11.2.7 Features of this circuit are (1) a control to regulate the voltage across the ambient compensation resistor and (2) the use of a chopper stabilized operational amplifier to minimize temperature drifts.

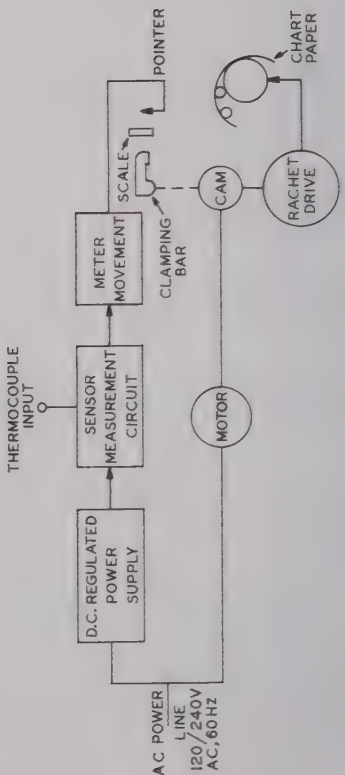
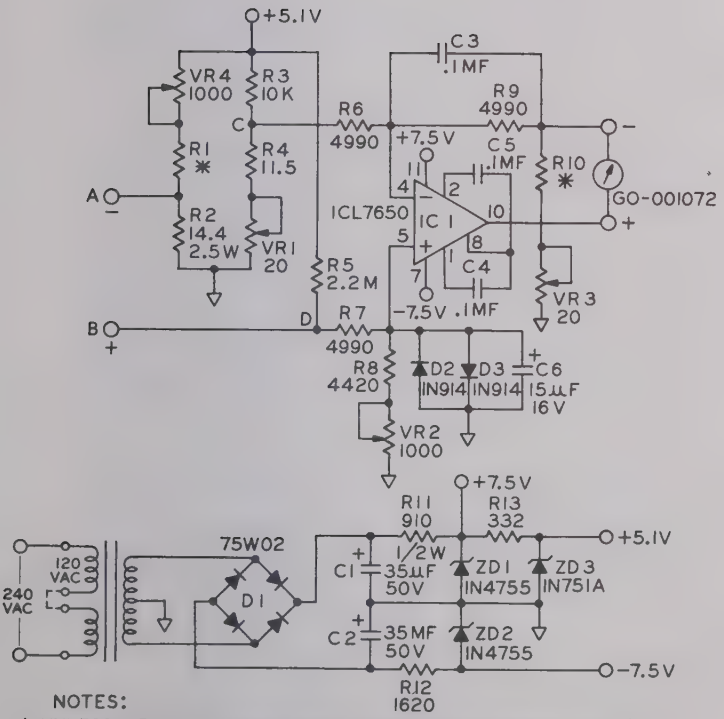


Figure 11-1. 2760-2 Basic System Diagram.



NOTES:

1. UNLESS OTHERWISE SPECIFIED; RESISTORS IN OHMS, 1%, 1/4W.
2. * THESE RESISTOR VALUES VARY ACCORDING TO RANGE AND THERMOCOUPLE USED.

Figure 11-2. 2760-2 Schematic Diagram.

SECTION XII
OPERATOR MAINTENANCE 2760-2

12.1 GENERAL

This section, as a supplement to Section VI of the manual, describes the advised minimal amount of operator maintenance for the 2760-2.

12.2 CALIBRATION CHECK

The components used in the 2760-2 have been selected to provide many years of service without the need of recalibration. However, calibration can be checked as follows:

The calibration of the thermocouple recorders can be checked by applying to the input a millivolt potential equivalent to the thermocouple output. Use a stable, low impedance (less than 10 ohm) millivolt source whose output is known or monitored to an accuracy of 0.1%. Tables showing the millivolt output relative to temperature for the various thermocouple types, in both Fahrenheit and Centigrade, are obtained easily from text books, thermocouple manufacturers, etc., and, therefore, are not covered in this manual.

NOTE: If the facilities required for calibration are not available, contact your nearest Simpson Authorized Service Center. These Centers are equipped and have trained personnel to make calibration checks and adjustments. A list of these Authorized Service Centers is provided on the last pages of the 2750-2 manual.

SECTION XIII
SERVICING INSTRUCTIONS 2760-2

13.1 GENERAL

This section, as a supplement to Section VII of the manual, describes the servicing instructions that must be performed by qualified service personnel.

13.2 TEMPERATURE SENSORS

TYPE	USABLE RANGE	RESISTANCE	DESCRIPTION	CAT. NO.
I/C Thermocouple	−20 °C to +675 °C (−4 °F to +1247 °F)	10Ω	Stainless Steel, 0.187″ x 5.0″, 10 foot leads	23245
I/C Thermocoule	−20 °C to +675 °C (−4 °F to +1247 °F)	10Ω	Stainless Steel overbraid, 235″, 20 ga.	21224
I/C/ Thermocouple	−20 °C to +675 °C (−4 °F to +1247 °F)	10Ω	Glass cloth overbraid, 34″, 30 ga.	21223
I/C Thermocouple	−20 °C to +675 °C (−4 °F to +1247 °F)	10Ω	Glass cloth overbraid, 137″, 24 ga.	21222
C/A Thermocouple	−20 °C to +1235 °C (−4 °F to +2255 °F)	10Ω	Stainless Steel, 0.187″ x 5.0″, 10 foot leads, 20 ga.	23246

AUTHORIZED SERVICE CENTERS
SIMPSON ELECTRIC COMPANY

853 Dundee Avenue, Elgin, Illinois 60120-3090 — Telex 72-2416
Phone (312) 697-2260 — FAX (312) 697-2272

★ Parts Sales & Analog Repair Service Only
★ ★ Parts, VOM & Analog Test Equipment Sales and Repair Service
▲ Same as (★ ★) Above Plus — Analog Panel Instrument Modification
▲ Full Line Digital, Analog & Control Products Equipment Sales, Parts & Repair Service Plus Digital/Analog Panel Instrument & Control Product Modification Service

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▲ **ALABAMA, Birmingham 35233**
Brownell Electro, Inc.
3028 Seventh Avenue, South
Tel. 205/323-4761

▲ **ALABAMA, Mobile 36607**
Arnold's Instruments
3258 Springhill Avenue
Tel. 205/478-3230

▲ **ALABAMA, Mobile 36617**
Brownell Electro, Inc.
3450 Armour Drive
Tel. 205/479-8581

▲ **ARIZONA, Phoenix 85040**
Metermaster, Inc.
4134 E. Wood Street, Suite 260
Tel. 602/437-1425

▲ **ARKANSAS, Little Rock 72209**
Brownell Electro, Inc.
7123 I-30, Suite 15
Tel. 501/562-2061

▲ **CALIFORNIA, Dublin 94568**
Standard Meter Laboratory
11815 Dublin Blvd.
Tel. 415/828-4837

▲ **CALIFORNIA, Santa Ana 92705**
Meter Craft
1931 Occidental
Tel. 714/973-8378

▲ **CALIFORNIA, Los Angeles 90040**
E. I. L. Instruments, Inc.
6212 Peachtree Street
Tel. 213/685-7020

▲ **CALIFORNIA, Los Angeles 90040**
Metermaster, Inc.
5646 Jillson Street
Tel. 213/685-4340

▲ **CALIFORNIA, Palo Alto 94303**
Metermaster, Inc.
3995 E. Bayshore Road
Tel. 415/968-0313

▲ **CALIFORNIA, San Diego 92123**
Metermaster/San Diego
8799 Balboa Avenue
Tel. 619/560-4841

▲ **CALIFORNIA, San Leandro 94577**
Coast Instrument Co.
14455 Wicks Blvd.
Tel. 415/483-3774

▲ **CALIFORNIA, Santa Clara 95054**
Dynametron
477 Gianni St.
Tel. 408/727-6531

▲ **CALIFORNIA, South Pasadena 91030**
Etalon Company
1323 Huntington Drive
Tel. 213/257-5410

★ ★ **CALIFORNIA, Wilmington 90744**
Wilmington Instrument Co.
332 N. Fries Avenue
Tel. 213/834-1133

▲ **COLORADO, Aurora 80010**
R & R Instrumentation Inc.
1554 Elmira St.
Tel. 303/364-8325

COLORADO, Denver 80219
Meter Master Instrument Corp.
2630 W. 2nd Avenue
Tel. 303/722-5766

CONNECTICUT, Hamden 06514
Kaufman Instrument Labs, Inc.
Chimney Square, Suite 1A
1125 Dixwell Ave.
Tel. 203/776-7201

CONNECTICUT, Middletown 06457
E. I. L. Instruments, Inc.
125 Coe Avenue
Tel. 203/346-6646

FLORIDA, Hialeah 33016
Kimball Electronic Lab., Inc.
8081 W. 21st Lane
Tel. 305/822-5792

★ ★ **FLORIDA, Miami 33136**
Florida Precision Instrument Corp.
800 N.W. 7th Avenue
Tel. 305/324-1731

FLORIDA, Miami 33166
Brownell Electro, Inc.
6850 N.W. 74th Street
Tel. 305/884-3072

FLORIDA, Orlando 32806
Brownell Electro, Inc.
307 - 27th St.
Tel. 305/843-6770

FLORIDA, Palm Bay 32907
E. I. L. Instruments, Inc.
1914 Canova St., S.E.
Tel. 305/725-8300

GEORGIA, Atlanta 30336
Process Measurement Co.
4509 Futon Industrial Blvd.
Tel. 404/696-7334

GEORGIA, Atlanta 30354
Brownell Electro, Inc.
3020 Commerce Way
Tel. 404/762-5181

HAWAII, Honolulu 96819
H.S.I. Inc.
2234 Hoone Place
Tel. 808/845-6402

ILLINOIS, Bridgeview 60455
E. I. L. Instruments, Inc.
9708 Industrial Drive
Tel. 312/430-2292

ILLINOIS, Chicago 60617
W. H. Leary Co., Inc.
8320 Stoney Island Avenue
Tel. 312/721-3832

ILLINOIS, Countryside 60525
Pacific Indicator Company
5320 East Avenue
Tel. 312/352-3500

ILLINOIS, Itasca 60143
Metermaster, Inc.
1100 W. Thorndale Rd.
Tel. 312/250-0606

INDIANA, Evansville
Electro-Lab Services Inc.
1302 N. Fulton 47710 (UPS)
P. O. Box 6301 47712 (Mail)
Tel. 812/423-5211

★ ★ **INDIANA, Fort Wayne 46818**
Weingart Inc.
14730 Lima Rd.
Tel. 219/637-5568

INDIANA, Indianapolis 46226
E. I. L. Instruments, Inc.
7061 Twin Oaks Dr., A/M
Tel. 317/545-1373

KANSAS, Kansas City 66106
Process Measurement Co.
3100 S. 44th Street
Tel. 913/384-2064

★ ★ **KANSAS, Overland Park 66212**
Brooks Electronics Inc.
10418 Metcalf
Tel. 913/648-3131

KANSAS, Wichita 67213
The Meter Shop
1650-6 S. Meridian
Tel. 316/945-8866

LOUISIANA, New Orleans 70123
Industrial Instrument Works
5745 Salmen Ave.
Tel. 504/733-8355

▲ **MARYLAND, Savage 20763**
Pyttronic Industries, Inc.
8220 Wellmoor Court
Tel. 301/792-0780

MARYLAND, Sparks 21152
E. I. L. Instruments, Inc.
10 Loveton Circle
Tel. 301/771-4800

MASSACHUSETTS, Burlington 01803
E. I. L. Instruments, Inc.
21 "A" Street
Tel. 617/272-9450

▲ **MASSACHUSETTS, Woburn 01801**
Brownell Electro, Inc.
10 Linscott Road
Tel. 617/935-7820

MICHIGAN, Ferndale 48220
Ram Meter, Inc.
1100 Hilton Road
Tel. 313/398-6767

MINNESOTA, Minneapolis 55427
Instrumentation Services, Inc.
957 Winnetka Avenue North
Tel. 612/544-8916

★ ★ **MISSISSIPPI, Pascagoula 39567**
Instrument Repair Service of Mississippi
1406 Live Oak Avenue
P.O. Box 1035
Tel. 601/769-2421

▲ **MISSOURI, St. Louis 63136**
C & S Instruments
5749 Helen Avenue
Tel. 314/383-4445

MISSOURI, St. Louis 63108-2699
I.S.L. Corp.
4354 Olive Street
Tel. 314/535-5760
Outside Missouri 1-800/325-8653

MISSOURI, St. Louis 63143
Scherrer Instruments Inc.
7170 Manchester Ave.
Tel. 314/644-5362

NEBRASKA, Lincoln 68507
EM Corp.
Subsd. of Winders & Geist, Inc.
6433 Havelock Avenue
Tel. 402/467-3541

NEBRASKA, Omaha 68117
Process Measurement Co.
4865 "G" Street
Tel. 402/734-2434

▲ **NEW JERSEY, Belleville 07109**
Miscorp
236 Washington Avenue
Tel. 201/751-1190

NEW JERSEY, Edison 08817
Brownell Electro, Inc.
84 Executive Ave.
Tel. 201/287-2030

NEW JERSEY, Newfoundland 07435
Hosica Laboratories
715 Route 23S
Tel. 201/697-6111

NEW JERSEY, Pennsauken 08109
E. I. L. Instruments, Inc.
7870 Airport Highway
Tel. 609/488-0474

NEW MEXICO, Albuquerque 87102
Instrument Service Laboratories
680 Haines Avenue NW
Tel. 505/842-1107

NEW YORK, Baldwin 11510
Measurement Devices, Inc.
834 Merrick Road
Tel. 516/546-2777 or 546-5392

NEW YORK, Chadwicks 13319
Utica/Central NY Mohawk Ltd.
One Newell Lane
Tel. 315/737-7328

NEW YORK, Clarence 14031
Trott Electronics Inc.
9020 Wehrle Drive
Tel. 716/634-8500

NEW YORK, Hauppauge 11787
E. I. L. Instruments, Inc.
180 Oser Avenue
Tel. 516/231-6333

NEW YORK, New York 10011-5287
Nilsson Electrical Laboratory, Inc.
111 - 8th Avenue
Tel. 212/675-7944

NEW YORK, Rochester 14623
Caltronix Inc.
2070 East Henrietta Rd.
Tel. 716/359-3780

NORTH CAROLINA, Charlotte 28206
Brownell Electro, Inc.
3201 Woodpark Blvd.
Tel. 704/597-1270

NORTH CAROLINA, Charlotte 28203
Trott Electronics, Inc.
307-Z West Tremont Avenue
Tel. 704/376-2237

NORTH CAROLINA, Raleigh 27604
Brownell Electro, Inc.
5245 North Boulevard
Tel. 919/876-6524

OHIO, Cleveland 44105
Pioneer-Standard Electronics
Instrumentation Division
4800 East 131st Street
Tel. 216/587-3600

OHIO, Cleveland 44136
Weschler Electric Corp.
16900 Foltz Parkway
Tel. 216/238-2550

OHIO, Dayton 45459
E. I. L. Instruments, Inc.
96A Westpark Drive
Tel. 513/435-2134

OKLAHOMA, Oklahoma City 73107
Huston-DePue Laboratories Inc.
536 N. Pennsylvania St.
Tel. 405/235-5469

★ ★ **OKLAHOMA, Tulsa 74120**
Agra Engineering Company
551 S. Quaker Avenue
Tel. 1-800-422-AGRA

OREGON, Portland 97217
Westcon, Inc.
5101 N. Interstate Ave.
Tel. 503/283-0132

PENNSYLVANIA, Philadelphia 19115
Sunshine Scientific Instruments Inc.
1810 Grant Avenue
Tel. 215/673-5600

PENNSYLVANIA, Pittsburgh 15221
E. I. L. Instruments, Inc.
1844 Ardmore Blvd.
Tel. 412/731-5230

PUERTO RICO, Rio Piedras 00926
B & C Calibration Center, Inc.
#55 Brema St.
Antonsanti Bldg.
Tel. 809/765-2788, 751-8375

SOUTH CAROLINA, Columbia 29210
Brownell Electro, Inc.
1319 St. Andrews Road
Tel. 803/772-6111

TENNESSEE, Knoxville 37922
Brownell Electro, Inc.
207 Center Park Drive, Suite 100
Tel. 615/966-3441

TENNESSEE, Memphis 38118
Brownell Electro, Inc.
3821 Getwell Road
Tel. 901/795-8487

TENNESSEE, Memphis 38104
Instrument Repair Service
419 N. Watkins St.
Tel. 901/278-0762

TENNESSEE, Nashville 37210
Brownell Electro, Inc.
1837 Air Lane Drive
Tel. 615/889-8230

TEXAS, Austin 78717
Colcom, Inc.
15527 Ranch Rd. 620
Tel. 512/244-6689

TEXAS, Dallas 75248
E. I. L. Instruments, Inc.
4394 Sunbelt Drive
Tel. 214/931-1236

TEXAS, Dallas 75229
Ultra Instrument Lab., Inc.
10031 Monroe, Suite 101
Tel. 214/357-0297

★ ★ **TEXAS, Garland 75041**
Metermaster, Inc.
2809 National Drive
Tel. 214/271-5671

TEXAS, Houston 77075
American Analog Company
9125 Grannis Street
Tel. 713/941-7265

TEXAS, Houston 77081
E. I. L. Instruments, Inc.
7385 Ashcroft Street
Tel. 713/271-3100

TEXAS, Houston 77023
Meters & Instruments Corp.
6428 Gulf Freeway
Tel. 713/644-1631

TEXAS, Odessa 79761
Whitlock Instrument
1306 North Texas
Tel. 915/337-3412

VIRGINIA, Springfield 22153
E. I. L. Instruments, Inc.
7643 Fullerton
Tel. 703/569-2611

VIRGINIA, Richmond 23234
Meter Metrics
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7400 White Pine Road
Tel. 804/275-1431

VIRGINIA, Virginia Beach 23462
E. I. L. Instruments Inc.
5801-A Arrowhead Drive
Tel. 804/499-3746

WASHINGTON, Seattle 98188
E. I. L. Instruments, Inc.
910 Industry Drive
Tel. 206/575-1888

WASHINGTON, Seattle 98105
Eicher-Richards Company
2727 N. E. Blakeley Street
P.O. Box 85719
Tel. 206/523-7888

★ ★ **WASHINGTON, Spokane 99223**
McCune's Instruments & Boiler Service
East 3418 - 22nd Avenue
Tel. 509/534-7774

WISCONSIN, Milwaukee 53202
EM Instruments Inc.
153 No. Milwaukee Street
Tel. 414/272-7799
In WI 1-800-472-1292

★ ★ **WYOMING, Lander 82520**
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